Environmental Monitoring of the Aerial Spraying of Insecticides Against the Spruce Budworm, in Québec, in 1985

Concentrations of Biological Insecticides in the Air of Seven Municipalities in the Vicinity of Treated Areas

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ABSTRACT

In 1985, as part of its sixteenth operation of aerial spraying of insecticides against the spruce budworm (Choristoneura fumiferana), the ministère de l'Énergie et des Ressources (MÉR) carried out a study for the second consecutive year to evaluate the concentrations of biological insecticides (Bacillus thuringiensis) in the air of seven municipalities located near the treated areas. A total of 288 24-hour air samples were taken from May 29 to August 26, 1985. Analysis of the samples showed concentrations varying from undetected (< 3 UFC* in the sample) to a maximum of 1 365.14 UFC-min/l of air (938.24 UFC/m^3 of air). However, the majority (84%) of the samples showed concentrations of less than 1 UFC-min/l. A relatively weak correlation was noted in the sampling period between the concentrations detected and the distance from the treated areas. This may be attributable to such factors as the wind or the size of the treated areas in the vicinity of the stations. This faint relationship may also be due partially to problems of contamination affecting the analysis laboratory, which also prevent firm conclusions from being formulated with regard to long-distance drift.

The results obtained in this study are comparable to those obtained in 1984 and show low-level contamination of the air of the municipalities studied. However, very high levels may be detected sporadically during spraying close to the stations.

* UFC: Units forming colonies from one or more spores.

TABLE OF CONTENTS

Acknowledgements ii

Abstract iii

Table of Contents iv

List of Tables v

List of Figures vi

1. Introduction 1

2. Territory 2

3. Methodology 2

    3.1 Spraying 2

    3.2 Insecticide Formulations 4

    3.3 Air Sampling 4

    3.4 Analytical Method 8

4. Results 9

    4.1 St-Patrice-de-Rivière-du-Loup 9

    4.2 Pohénégamook 10

    4.3 Ste-Florence 10

    4.4 Gaspé 10

    4.5 Grande-Vallée 10

    4.6 Baie-St-Paul 10

    4.7 Pointe-Aux-Anglais 10

5. Discussion 18

Appendix: Composition of Tween 80 and Nutrient Agar 28

Bibliography 29

LIST OF TABLES

TABLE 1: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at St-Patrice-de-Rivière-du-Loup 11

TABLE 2: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Pohénégamook 12

TABLE 3: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Ste-Florence 13

TABLE 4: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Gaspé 14

TABLE 5: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Grande-Vallée 15

TABLE 6: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Baie-St-Paul 16

TABLE 7: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Pointe-Aux-Anglais 17

LIST OF FIGURES

FIGURE 1: Areas treated with biological insecticide (B.t.) during the spraying program against the spruce budworm carried out in Québec in 1985 3

FIGURE 2: Diagram of apparatus used in sampling air for biological insecticide in 1985 7

FIGURE 3: Histogram of concentrations of biological insecticide (B.t.) detected at St-Patrice-de-Rivière-du-Loup during spraying against the spruce budworm in 1985 21

FIGURE 4: Histogram of concentrations of biological insecticide (B.t) detected at Pohénégamook during spraying against the spruce budworm in 1985 22

FIGURE 5: Histogram of concentrations of biological insecticide (B.t.) detected at Ste-Florence during spraying against the spruce budworm in 1985 23

FIGURE 6: Histogram of concentrations of biological insecticide (B.t.) detected at Gaspé during spraying against the spruce budworm in 1985 24

FIGURE 7: Histogram of concentrations of biological insecticide (B.t.) detected at Grande-Vallée during spraying against the spruce budworm in 1985 25

FIGURE 8: Histogram of concentrations of biological insecticide (B.t.) detected at Baie-St-Paul during spraying against the spruce budworm in 1985 26

FIGURE 9: Histogram of concentrations of biological insecticide (B.t.) detected at Pointe-Aux-Anglais during spraying against the spruce budworm in 1985 27

1. INTRODUCTION

In the spring of 1985, as part of its program of controlling harmful insects in the forest environment and pursuant to Order in Council 192-85, the ministère de l'Énergie et des Ressources (MÉR) carried out its sixteenth aerial insecticide spraying operation to reduce damage caused by the spruce budworm (Choristoneura fumiferana).

Since several of the territories treated are located near residential areas, the MÉR carried out a monitoring program to evaluate the drift of insecticides in some municipalities and to measure the concentrations in the air to which the citizens of these municipalities may be exposed. Despite the safety of Bacillus thuringiensis-based biological insecticides, these products were sampled and this report discusses the results obtained in the study. A parallel program dealing with the chemical insecticide is dealt with in another report.

2. TERRITORY

Spraying carried out by the MÉR in 1985 covered an area of 667 418 hectares in the Bas St-Laurent, Gaspésie, Saguenay-Lac-St-Jean, Québec, and Côte-Nord regions (Fig. 1). Of this area, 184 455 ha (28%) were treated with the chemical insecticide fenitrothion and 482 963 ha (72%) with the biological insecticides dealt with in this report. Spraying with biological insecticides over an area of 36 777 ha in private forests was also carried out by agencies other than the MÉR. These areas are not shown in Figure 1 because of the small size of the blocks sprayed, but they were taken into consideration in interpreting the results.

3. METHODOLOGY

3.1 Spraying

The biological spraying program was carried out from June 3 to July 5 with Constellation L-749, DC-4G, and DC-6 four-engine aircraft and Agcat, Super Cub, Piper Pawnee, Turbo Thrush, and Bull Thrush single-engine aircraft. The four-engine aircraft were guided by Litton^{tm} inertial navigation systems while the single-engine aircraft were flown by visual navigation. The spraying systems consisted of booms fitted with open nozzles installed on the four-engine aircraft and Mini Micronair^{tm} AU-5000 atomizers installed on the single-engine aircraft.

The blocks sprayed with biological insecticides received only one application. Several blocks initially in the program were, however, not sprayed because of a decrease in larvae populations to below the harmful level.

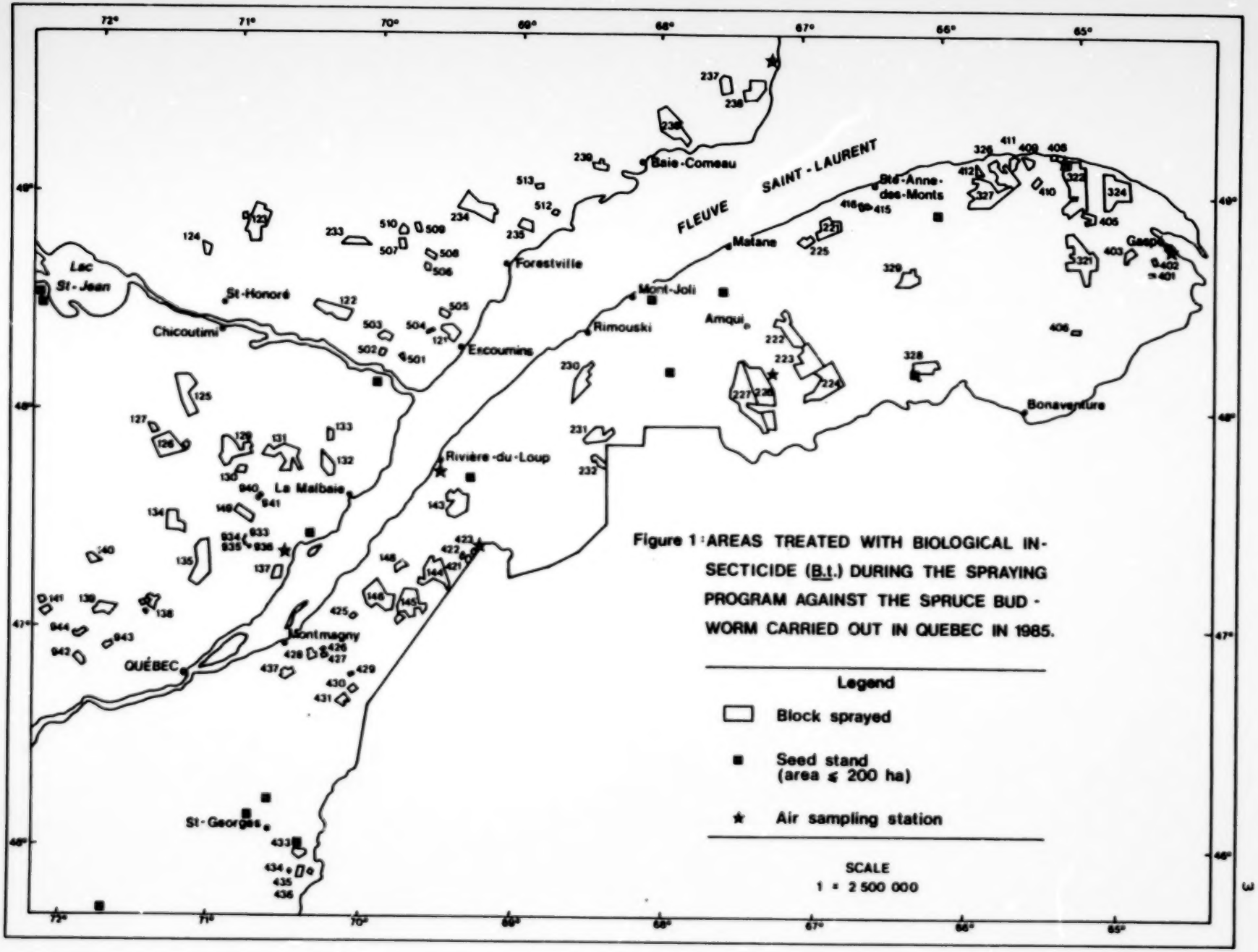


Figure 1 : AREAS TREATED WITH BIOLOGICAL INSECTICIDE (B.t.) DURING THE SPRAYING PROGRAM AGAINST THE SPRUCE BUD-WORM CARRIED OUT IN QUEBEC IN 1985.

3.2 Insecticide Formulations

The biological insecticides used operationally by the MÉR or the other agencies were Thuricide^{tm} 48 LV, Novabac^{tm} 3, and Futura^{tm} FC. Other products -- SAN-415^{tm}, Thuricide^{tm} 64B, Futura^{tm} XLV, Biobit^{tm} 64B, and Dipel^{tm} 176 -- were also sprayed on an experimental basis over very small areas. It should be mentioned that all these insecticides are Bacillus thuringiensis var. kurstaki spore and crystal-based products.

3.3 Air Sampling

Seven municipalities in eastern Québec, namely St-Patrice-de-Rivière-du-Loup, Pohénégamook, Ste-Florence, Gaspé, Grande-Vallée, Baie-St-Paul, and Pointe-aux-Anglais, were selected for the study. The seven municipalities are located near areas treated with biological products. The St-Patrice station was chosen because of its proximity to the MÉR operations base at Notre-Dame-du-Portage. Most of the stations are located downwind of the prevailing westerly winds in relation to the areas treated.

In each of the seven municipalities, the sampling station was located in the backyard of a private house on open, relatively flat ground. In the case of Gaspé, the station was located right next to the Sanatorium Ross. The distance between each station and the nearest treated block varied from 1 to 13 km (Fig. 1).

St-Patrice-de-Rivière-du-Loup

The station was located 3.8 km northeast of the MÉR operations base, midway between the base and the City of Rivière-du-Loup. Samples were taken at this station to measure the possible

presence of B.t. spores due to storage of biological insecticides at the base, as well as to evaluate the drift from treated blocks. It should be pointed out in this regard that the station was 13 km from the closest treated block.

Pohénégamook

The station was located 8 km south of St-Eleuthère and less than 1 km from the American border. The nearest treated block was located 1 km from the station.

Ste-Florence

The station was located 5.6 km south of Ste-Florence and 1 km from the nearest treated area.

Gaspé

Samples were taken in the downtown area of the City of Gaspé, on the promontory on which the Sanatorium Ross de Gaspé is located. The closest area where biological spraying took place was 10 km from the station.

Grande-Vallée

Sampling was carried out 3.5 km southwest of the village and 4 km from the nearest treated block.

Baie-St-Paul

The station was located 13 km southwest of Baie-St-Paul in the St-Placide-de-Charlevoix area. The nearest treated block was 5.7 km from the station.

Pointe-aux-Anglais

The sampling station was 1.5 km south of the village and 10.5 km from the nearest treated block.

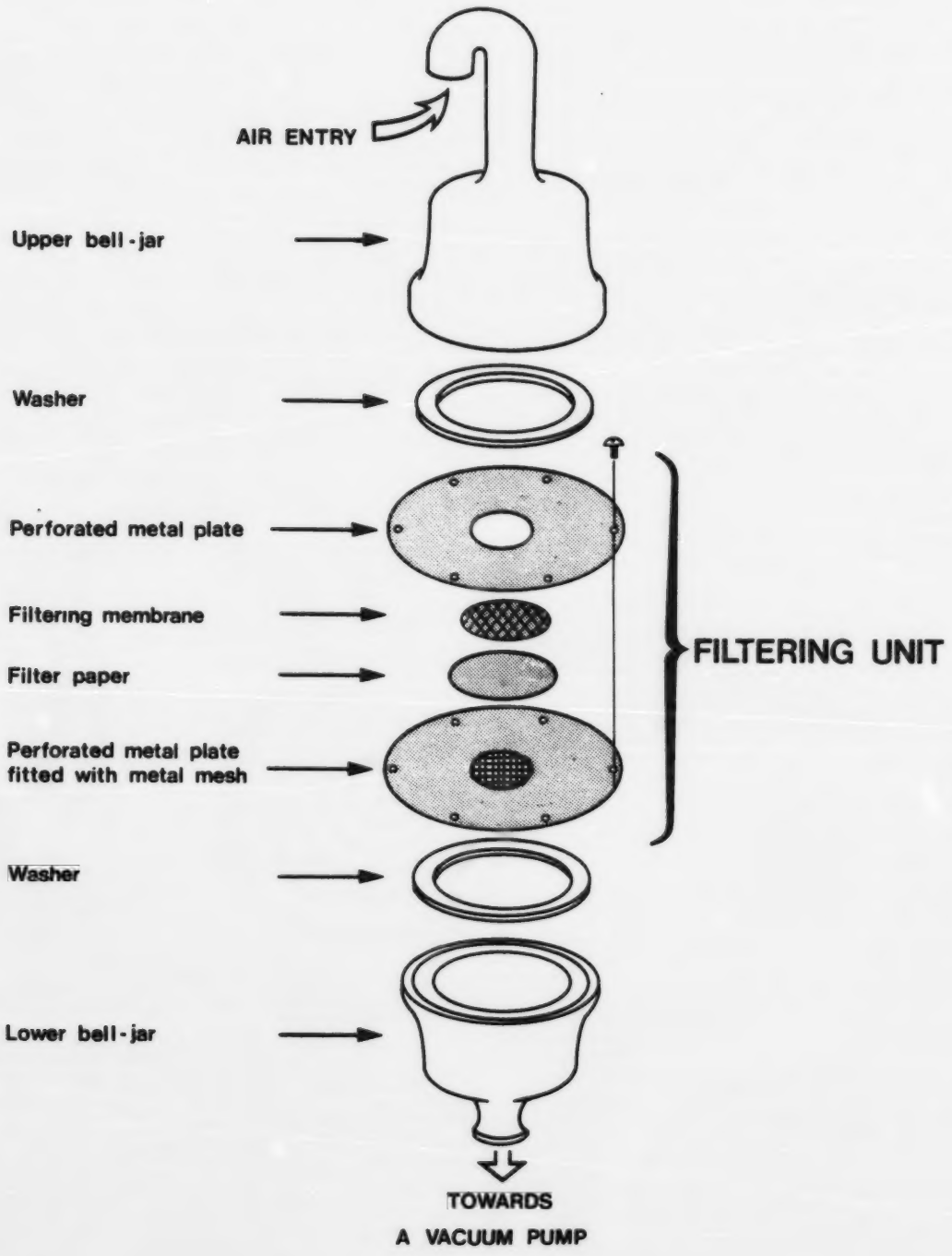
A total of 40 to 43 air samples were taken at each of the stations from May 29 to July 11, 1985, which was the spraying period. At the St-Patrice station, considering the proximity of the operations base where the insecticides are stored, a weekly sample was taken until August 26 for a total of 50 samples. Each approximately 24-hour sample was taken with Model 88 Sierra-Misco^{tm} sampling equipment at a rate of 32 l/min.

B.t. spores were retained by a Millipore^{tm} filtering membrane of cellulose ester, with a porosity of 0.45 μ and a diameter of 4.7 cm. This membrane was placed on Whatman^{tm} filter paper between two perforated stainless steel plates. This device formed the filtering unit (Fig. 2). After assembly, the filtering unit was sterilized with ethylene oxide under hospital conditions and remained sealed until use.

During sampling, the filtering unit was installed between two presterilized glass bell-jars. The system was sealed using rubber washers. The apparatus, illustrated in Figure 2, was then connected to a pump. After samples were taken, the filtering unit was placed in a sterile petri dish and kept in a freezer until laboratory analysis.

Similar filtering units were used in 1984 except that the filter was placed between two perforated petri dishes instead of metal plates. The tests carried out on this apparatus proved to be highly effective in retaining B.t. spores (Major et al., 1985).

Figure 2: Diagram of apparatus used in sampling air for biological insecticides in 1985.



3.4 Analytical Method

The filtering unit was dismantled and the filter placed in 200 ml of sterile Tween 80 (0.1%, pH 7.2). The solution was shaken for 30 minutes on a shaking platform. Some sterile antifoaming drops were then added. The filter was next rinsed with 50 ml of sterile water and placed on nutrient agar. The spores adhering to it were later counted.

The total volume of 250 ml was shaken for 30 seconds for better homogenization. Two 50 ml volumes and one 100 ml volume were taken and analysed by vacuum filtration using funnels fitted with Millipore^{tm} (0.45 μ porosity) filters. The filters were then placed on nutrient agar for a 24-hour period of incubation at 29°C.

The B.t. colonies were counted by selecting the petri dishes containing between 20 and 80 colonies and considering only colonies similar to B.t., i.e. tan, flat, and rough in appearance. The percentage of B.t. was determined on a petri dish which had been reincubated for a total of 50 hours. This incubation period enabled the spore to develop and the crystal (protein body) characteristic of B.t. to be released. From this petri dish, slide smears were prepared from 20 colonies and stained, using the method developed by Smirnoff (1962) to identify the B.t. crystals.

The remaining 50 ml volume was kept at 4°C. If more than 80 B.t. colonies were counted on the filtering membrane, smaller volumes were then filtered. The quantity retained by the sampling filter was added to the total number of UFC* extrapolated for 250 ml.

* UFC: Units forming colonies from one or more spores

All manipulations were carried out under a laminar flux biological hood to reduce contamination. Samples before and after filtration were analysed to ensure that the equipment used was sterile.

The composition of Tween 80 and nutrient agar is given in detail in the appendix.

4. RESULTS

Tables 1 through 7 show the results obtained for each day at each of the seven municipalities throughout the spraying program. These results are expressed in integrated concentrations* (UFC-min/l of air) and in average concentrations (UFC/m^3 of air). It should be noted that some samples were invalidated because the filter broke or the pump failed to operate. For other samples, only the presence could be confirmed without accurate measurement because of a break in the flow and an unknown total volume of air. The results in each of the seven municipalities are given below.

4.1 St-Patrice-de-Rivière-du-Loup

For the 43 air samples collected daily from May 29 to July 10, concentrations vary from undetected** (15 samples) to a maximum of 10.59 UFC-min/l (7.67 UFC/m^3). For the seven samples collected on a weekly basis from July 16 to August 26, B.t. was detected on one occasion but the result could not be quantified.

* Integrated concentration is the quotient of the number of UFC present in the sample over the flow rate (l/min) of the sampling apparatus.

** Undetected: less than 3 UFC in the sample

4.2 Pohénégamook

A total of 42 air samples were collected from May 29 to July 9. Results vary from undetected (24 samples) to 42.20 UFC-min/l (29.43 UFC/m^3).

4.3 Ste-Florence

Note that the first ten samples were invalidated because the pump operated improperly. For the 31 subsequent samples taken from June 8 to July 8, the results vary from undetected (five samples) to a maximum of 1 365.14 UFC-min/l (938.24 UFC/m^3).

4.4 Gaspé

Of the 42 air samples taken from May 30 to July 10, only 16 showed the presence of B.t. and the maximum concentration found was 87.55 UFC-min/l (61.14 UFC/m^3).

4.5 Grande-Vallée

At this location, B.t. was detected in 21 of the 42 samples taken from May 29 to July 10. The maximum concentration found was 21.01 UFC-min/l (14.56 UFC/m^3).

4.6 Baie-St-Paul

Forty air samples were taken from May 31 to July 10. Analysis showed concentrations varying from undetected (19 samples) to a maximum concentration of 14.40 UFC-min/l (10 UFC/m^3).

4.7 Pointe-aux-Anglais

At this station in the Côte-Nord region, the biological insecticide was detected in 22 samples out of the 41 taken from May 31 to July 10. The maximum concentration found was 17.36 UFC-min/l (12.05 UFC/m3).

TABLE 1: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at St-Patrice-de-Rivière-du-Loup

DATE[1]	Time-integrated Concentrations (U.F.C.-min/l)	Average Concentrations over 24 Hours (U.F.C./m^3)
85-05-29	0.26	0.18
30	U.D.	U.D.
31	0.76	0.53
06-01	0.86	0.60
02	0.56	0.37
03	U.D.	U.D.
04	U.D.	U.D.
05	Presence	Presence
06	0.41	0.28
07	10.59	7.67
08	3.26	2.27
09	2.23	1.47
10	0.14	0.10
11	0.17	0.12
12	Presence	Presence
13	U.D.	U.D.
14	U.D.	U.D.
15	U.D.	U.D.
16	0.86	0.56
17	0.15	0.11
18	0.41	0.28
19	0.19	0.13
20	0.26	0.18
21	U.D.	U.D.
22	Presence	Presence
23	0.25	0.17
24	U.D.	U.D.
25	U.D.	U.D.
26	*	*
27	0.36	0.26
28	0.35	0.24
29	U.D.	U.D.
30	0.81	0.55
07-01	0.32	0.23
02	U.D.	U.D.
03	U.D.	U.D.
04	0.46	0.32
05	1.22	0.80
06	Presence	Presence
07	Presence	Presence
08	U.D.	U.D.
09	U.D.	U.D.
10	U.D.	U.D.
16	U.D.	U.D.
23	U.D.	U.D.
30	U.D.	U.D.
08-07	Presence	Presence
15	U.D.	U.D.
20	U.D.	U.D.
26	*	*

1 Date sampling period began
U.D. Undetected (<3 U.F.C. in sample)
* Sample invalidated

TABLE 2: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Pohénégamook

DATE[1]	Time-Integrated Concentrations (U.P.C.-min/l)	Average Concentrations over 24 Hours (U.P.C./m^3)
85-05-29	U.D.	U.D.
30	16.07	11.27
31	0.24	0.17
06-01	4.71	3.27
02	U.D.	U.D.
03	0.43	0.30
04	0.51	0.35
05	U.D.	U.D.
06	0.35	0.24
07	42.20	29.43
08	0.53	0.37
09	*	*
10	0.40	0.28
11	U.D.	U.D.
12	Presence	Presence
13	U.D.	U.D.
14	U.D.	U.D.
15	U.D.	U.D.
16	U.D.	U.D.
17	Presence	Presence
18	0.21	0.15
19	0.22	0.15
20	*	*
21	U.D.	U.D.
22	*	*
23	U.D.	U.D.
24	U.D.	U.D.
25	U.D.	U.D.
26	U.D.	U.D.
27	U.D.	U.D.
28	U.D.	U.D.
29	U.D.	U.D.
30	U.D.	U.D.
07-01	U.D.	U.D.
02	U.D.	U.D.
03	U.D.	U.D.
04	U.D.	U.D.
05	0.79	0.55
06	0.19	0.13
07	U.D.	U.D.
08	U.D.	U.D.
09	U.D.	U.D.

1 Date sampling period began
U.D. Undetected (< 3 U.P.C. in sample)
* Sample invalidated

TABLE 3: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Ste-Florence

DATE[1]	Time-Integrated Concentrations (U.F.C.-min/l)	Average Concentrations over 24 Hours (U.F.C./m^3)
85-05-29	*	*
30	*	*
31	*	*
06-01	*	*
02	*	*
03	*	*
04	*	*
05	*	*
06	*	*
07	*	*
08	1365.14	938.24
09	Presence	Presence
10	17.09	12.52
11	14.01	9.73
12	361.17	253.45
13	0.84	0.58
14	1.32	0.92
15	2.12	1.48
16	0.84	0.58
17	15.99	11.22
18	0.51	0.36
19	0.51	0.35
20	0.41	0.29
21	0.34	0.24
22	U.D.	U.D.
23	0.94	0.68
24	Presence	Presence
25	U.D.	U.D.
26	1.16	0.81
27	0.34	0.24
28	0.10	0.07
29	U.D.	U.D.
30	7.68	5.26
07-01	U.D.	U.D.
02	0.34	0.24
03	0.93	0.64
04	0.16	0.11
05	U.D.	U.D.
06	0.26	0.18
07	11.56	8.20
08	1.26	0.90

1 Date sampling period began
U.D. Undetected (< 3 U.F.C. in sample)
* Sample invalidated

TABLE 4: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Gaspé

DATE[1]	Time-Integrated Concentrations (U.F.C.-min/l)	Average Concentrations over 24 Hours (U.F.C./m^3)
85-05-30	U.D.	U.D.
31	U.D.	U.D.
06-01	U.D.	U.D.
02	0.09	0.06
03	0.24	0.17
04	U.D.	U.D.
05	U.D.	U.D.
06	U.D.	U.D.
07	U.D.	U.D.
08	U.D.	U.D.
09	U.D.	U.D.
10	U.D.	U.D.
11	U.D.	U.D.
12	0.94	0.67
13	U.D.	U.D.
14	8.24	5.66
15	6.14	4.34
16	U.D.	U.D.
17	0.23	0.16
18	0.11	0.08
19	U.D.	U.D.
20	U.D.	U.D.
21	0.27	0.19
22	U.D.	U.D.
23	U.D.	U.D.
24	U.D.	U.D.
25	U.D.	U.D.
26	4.52	3.14
27	U.D.	U.D.
28	U.D.	U.D.
29	U.D.	U.D.
30	U.D.	U.D.
07-01	U.D.	U.D.
02	87.55	61.14
03	1.57	1.10
04	23.09	15.87
05	51.27	36.75
06	2.57	1.79
07	U.D.	U.D.
08	0.17	0.12
09	0.17	0.12
10	U.D.	U.D.

1 Date sampling period began
U.G. Undetected (< 3 U.F.C. in sample)
* Sample invalidated

TABLE 5: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 à Grande-Vallée

DATE[1]	Time-Integrated Concentrations (U.F.C.-min/l)	Average Concentrations over 24 Hours (U.F.C./m^3)
85-05-30	U.D.	U.D.
31	0.10	0.07
06-01	0.30	0.21
02	U.D.	U.D.
03	0.27	0.19
04	U.D.	U.D.
05	0.29	0.20
06	U.D.	U.D.
07	U.D.	U.D.
08	U.D.	U.D.
09	U.D.	U.D.
10	U.D.	U.D.
11	U.D.	U.D.
12	U.D.	U.D.
13	U.D.	U.D.
14	0.70	0.49
15	U.D.	U.D.
16	0.60	0.42
17	16.28	11.33
18	0.23	0.16
19	U.D.	U.D.
20	0.10	0.07
21	U.D.	U.D.
22	U.D.	U.D.
23	0.35	0.24
24	U.D.	U.D.
25	U.D.	U.D.
26	1.43	0.99
27	0.09	0.06
28	0.22	0.15
29	0.14	0.10
30	U.D.	U.D.
07-01	U.D.	U.D.
02	U.D.	U.D.
03	U.D.	U.D.
04	16.49	11.48
05	21.01	14.56
06	1.58	1.10
07	0.42	0.29
08	0.53	0.37
09	0.17	0.12
10	0.45	0.31

1 Date sampling period began
U.D. Undetected (< 3 U.F.C. in sample)
* Sample invalidated

TABLE 6: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Baie-St-Paul

DATE[1]	Time-Integrated Concentrations (U.F.C.-min/l)	Average Concentrations over 24 Hours (U.F.C./m^3)
85-05-31	*	*
06-01	2.33	1.66
02	13.77	9.56
03	U.D.	U.D.
04	U.D.	U.D.
05	1.17	0.88
06	14.40	10.00
07	6.39	4.44
08	U.D.	U.D.
09	U.D.	U.D.
10	0.35	0.26
11	U.D.	U.D.
12	*	*
13	0.20	0.14
14	U.D.	U.D.
15	0.17	0.12
16	1.09	0.76
17	Presence	Presence
18	0.52	0.36
19	0.14	0.10
20	U.D.	U.D.
21	0.39	0.28
22	U.D.	U.D.
23	U.D.	U.D.
24	U.D.	U.D.
25	U.D.	U.D.
26	0.13	0.09
27	0.13	0.09
28	U.D.	U.D.
29	U.D.	U.D.
30	1.37	0.95
07-01	0.10	0.09
02	U.D.	U.D.
03	U.D.	U.D.
04	U.D.	U.D.
05	U.D.	U.D.
06	0.12	0.07
07	-	-
08	U.D.	U.D.
09	U.D.	U.D.
10	Presence	Presence

1 Date sampling period began
U.D. Undetected (< 3 U.F.C. in sample)
* Sample invalidated

TABLE 7: Concentrations of biological insecticide (B.t.) detected in air samples taken in 1985 at Pointe-aux-Anglais

DATE[1]	Time-Integrated Concentrations (U.F.C.-min/l)	Average Concentrations over 24 Hours (U.F.C./m^3)
85-05-31	0.43	0.30
06-01	0.36	0.25
02	U.D.	U.D.
03	0.76	0.53
04	0.14	0.10
05	0.16	0.11
06	U.D.	U.D.
07	1.76	1.22
08	1.33	0.92
09	Presence	Presence
10	U.D.	U.D.
11	0.61	0.42
12	0.25	0.17
13	0.39	0.27
14	U.D.	U.D.
15	U.D.	U.D.
16	U.D.	U.D.
17	U.D.	U.D.
18	Presence	Presence
19	U.D.	U.D.
20	0.12	0.08
21	U.D.	U.D.
22	U.D.	U.D.
23	U.D.	U.D.
24	*	*
25	U.D.	U.D.
26	0.14	0.10
27	U.D.	U.D.
28	12.72	8.83
29	0.56	0.39
30	0.14	0.10
07-01	9.11	6.32
02	0.12	0.08
03	0.10	0.07
04	0.74	0.51
05	17.36	12.05
06	U.D.	U.D.
07	U.D.	U.D.
08	U.D.	U.D.
09	U.D.	U.D.
10	U.D.	U.D.

1 Date sampling period began
U.D. Undetected (< 3 U.F.C. in sample)
* Sample invalidated

5. DISCUSSION

Wide variations in concentrations of B.t. were noted throughout the sampling program in all municipalities. Despite the broad spread between minimum and maximum concentrations, most concentrations were very low: only 16% (43 out of 266) of the samples analysed quantitatively showed concentrations greater than 1 UFC-min/l.

We have compiled the results in histogram form in figures 3 through 9, in order to visualize the variation in concentrations and the possible correlation between concentrations and spraying carried out by the MÉR in the surrounding area. Examination of the figures reveals a relatively weak correlation between the distance of the treated areas and the concentrations found. This phenomenon may be explained by such factors as wind direction and velocity and the size of the treated area near the stations.

Before pursuing the discussion further, it is important to mention that contamination problems were noted sporadically in the sterile samples when analyses were conducted in the microbiology laboratory. Certain abnormal results may also stem from these problems. For example, concentrations detected before the spraying program on June 1 and 2 at Baie-St-Paul (Fig. 8) and on May 30 and June 1 at Pohénégamook (Fig. 4) are probably attributable to this problem. Consequently, it is also dangerous to attribute certain concentrations to a long-distance drift of the product as observed June 30 and July 7 at Ste-Florence (Fig. 5), June 6 at Baie-St-Paul (Fig. 8) and July 1 and 5 at Pointe-aux-Anglais (Fig. 9).

There were several interesting results at the Ste-Florence station (Fig. 5). The maximum concentration detected June 8 (1 365.14 UFC-min/l) is very high compared to the overall results. It may

be explained by the fact that blocks 226 and 227 were almost completely treated during the sampling period. Moreover, a higher dosage was applied to an area of some 2 500 ha, about 10 km from the station. Lastly, the spraying line nearest the station was less than 1 km away. With regard to the concentrations found on June 10, 11, and 12, the first may be residual in nature as a result of the applications made during the two previous days. As for the last two concentrations, it should be emphasized that spraying in private forests was carried out less than 20 km away by an agency other than the MER. Finally, the most probable explanation for the concentration of B.t. detected July 7at this station is contamination during analysis, as mentioned previously.

The Rivière-du-Loup station also merits special analysis. We must remember that this station, in addition to measuring the drift out of the nearby treated areas, was aimed at evaluating air contamination due to storage of biological insecticides at the operations base next door. Figure 3 shows the presence of low-level contamination throughout the sampling period, with the exception of several days when the product was sprayed nearby. The lowest maximum concentration (10.59 UFC-min/l) was recorded at this station. Finally, an unquantifiable concentration was detected August 7, or about one month after the spraying program had ended.

The results obtained during this monitoring study show a certain correlation with those obtained in 1984 in two municipalities of the Bas St-Laurent - Gaspésie region (Major et al., 1985). In that study, 54% of the results were less than 1 UFC-min/l and the maximum concentrations recorded were 18.96 and 132.59 UFC-min/l at St-Honoré and Causapscal, respectively. In 1985, the overall results were lower: 84% of the samples were less than

1 UFC-min/l. With the exception of the 1 365.14 UFC-min/l concentration found at Ste-Florence, the maximum concentrations at the 1985 stations vary from 10.59 to 87.55 UFC-min/l, or maximum concentrations comparable to those found in 1984.

It may therefore be concluded that air contamination generally remained at a low level in the municipalities located near the treated areas. However, higher concentrations may be noted sporadically when spraying has been carried out in the proximity of the stations.

We discussed the health risks from absorption of B.t. in a previous report (Major et al., 1985). Even much higher concentrations than those found in this study present only a very minimal hazard for the populations concerned.

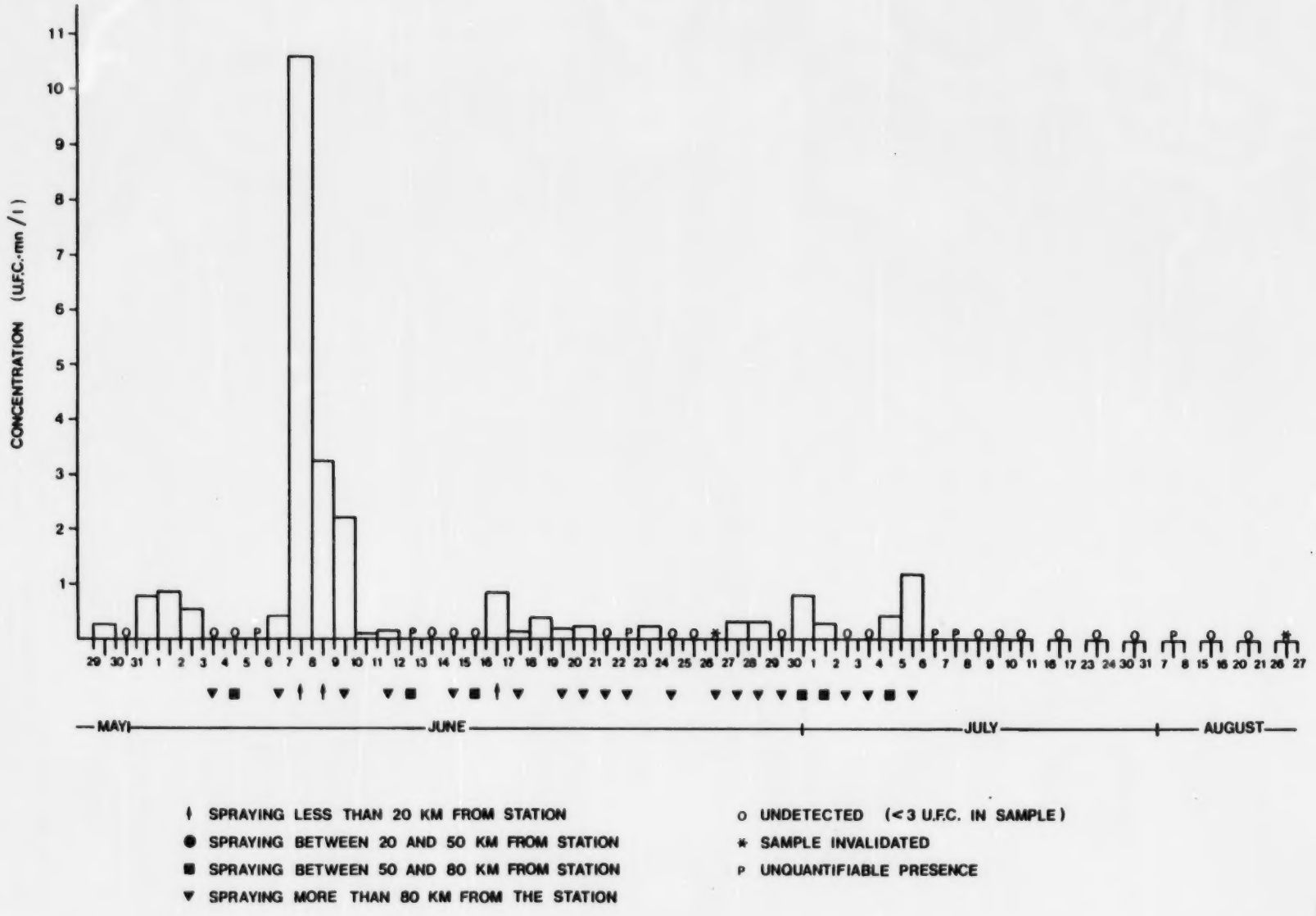

CONCENTRATION (U.F.C./ml)
11
10
9
8
7
6
5
4
3
2
1
29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11 16 17 23 24 30 31 7 8 15 16 20 21 26 27
MAY
JUNE
JULY
AUGUST
SPRAYING LESS THAN 20 KM FROM STATION
SPRAYING BETWEEN 20 AND 50 KM FROM STATION
SPRAYING BETWEEN 50 AND 80 KM FROM STATION
SPRAYING MORE THAN 80 KM FROM THE STATION
o UNDETECTED (< 3 U.F.C. IN SAMPLE)
* SAMPLE INVALIDATED
P UNQUANTIFIABLE PRESENCE

Figure 3: Histogram of concentrations of biological insecticide (B.t.) detected at St-Patrice-de-Rivière-du-Loup during spraying against the spruce budworm in 1985.

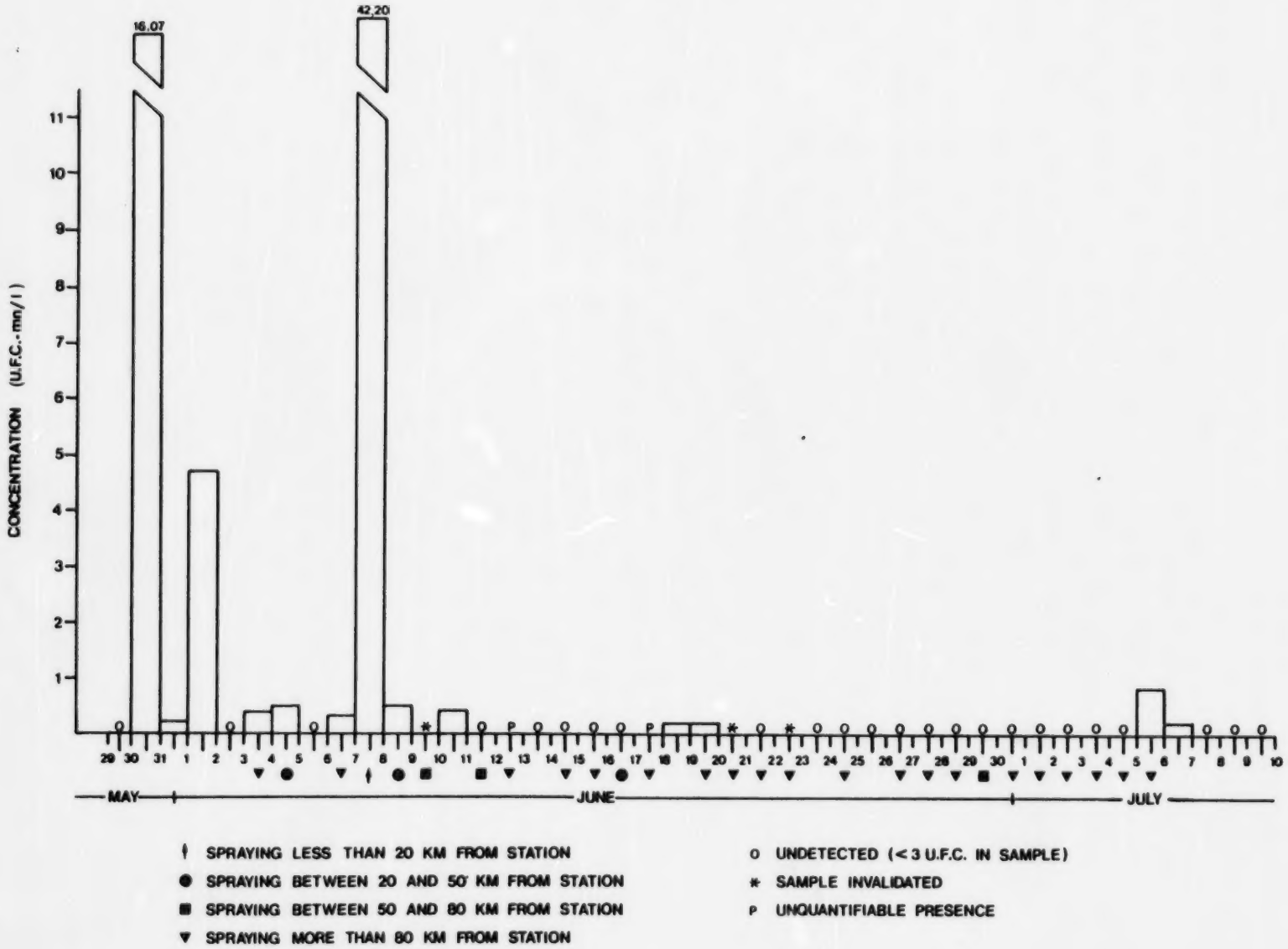

16.07
42.20
CONCENTRATION (U.F.C.-mn/l)
11
10
9
8
7
6
5
4
3
2
1
29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10
MAY
JUNE
JULY
SPRAYING LESS THAN 20 KM FROM STATION
SPRAYING BETWEEN 20 AND 50 KM FROM STATION
SPRAYING BETWEEN 50 AND 80 KM FROM STATION
SPRAYING MORE THAN 80 KM FROM STATION
O UNDETECTED (< 3 U.F.C. IN SAMPLE)
* SAMPLE INVALIDATED
P UNQUANTIFIABLE PRESENCE

Figure 4: Histogram of concentrations of biological insecticide (B.t.) detected at Pohénégamook during spraying against the spruce bud - worm in 1985.

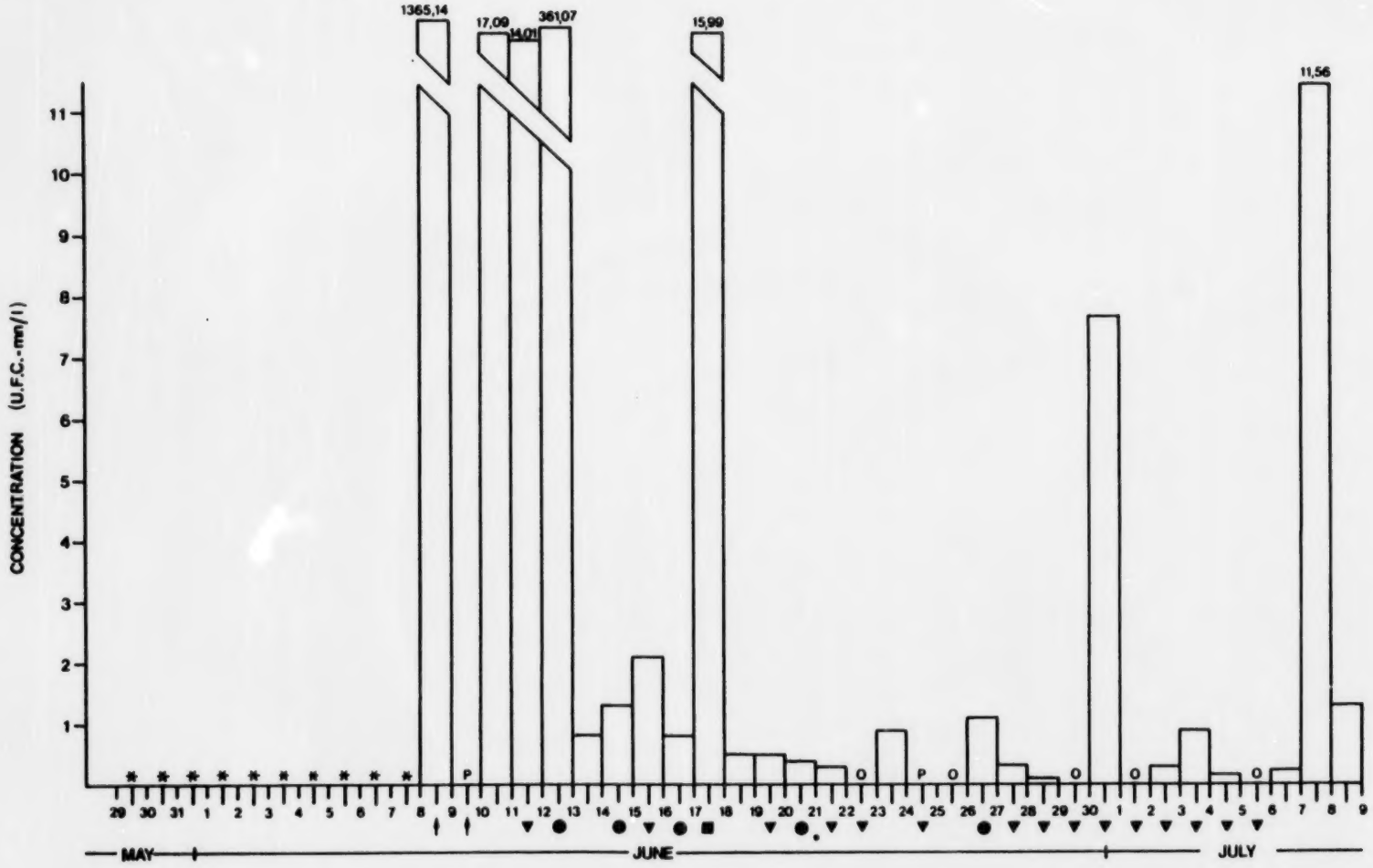


Figure 5 : Histogram of concentrations of biological insecticide (B.t.) detected at Ste-Florence during spraying against the spruce budworm in 1985.

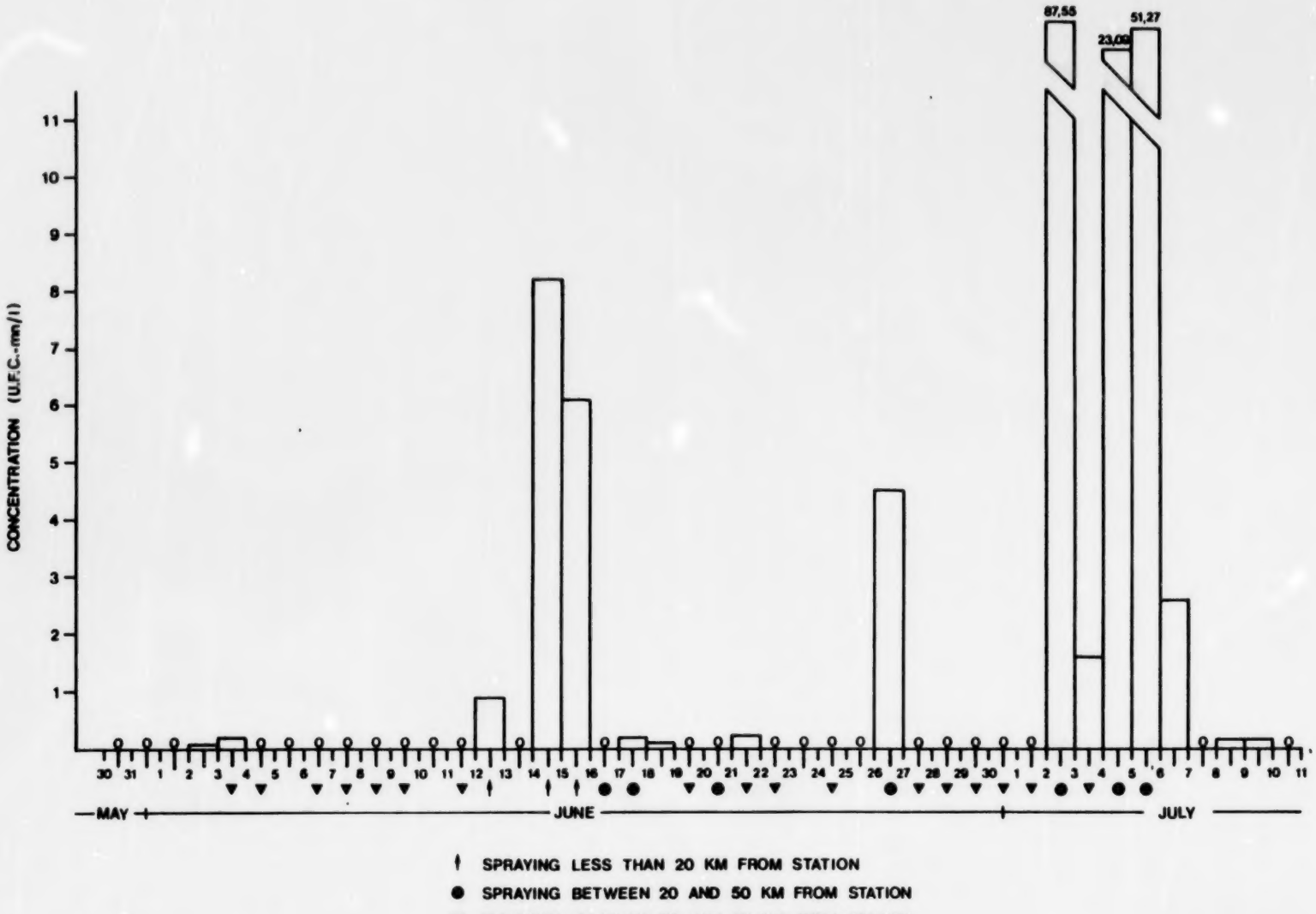

87,55
51,27
23,09
CONCENTRATION (U.F.C.-mm/l)
11
10
9
8
7
6
5
4
3
2
1
30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11
MAY
JUNE
JULY
SPRAYING LESS THAN 20 KM FROM STATION
SPRAYING BETWEEN 20 AND 50 KM FROM STATION
SPRAYING BETWEEN 50 AND 80 KM FROM STATION
SPRAYING MORE THAN 80 KM FROM STATION
UNDETECTED (< 3 U.F.C. IN SAMPLE)

Figure 6: Histogram of concentrations of biological insecticide (B.t.) detected at Gaspé during spraying against the spruce budworm in 1985.

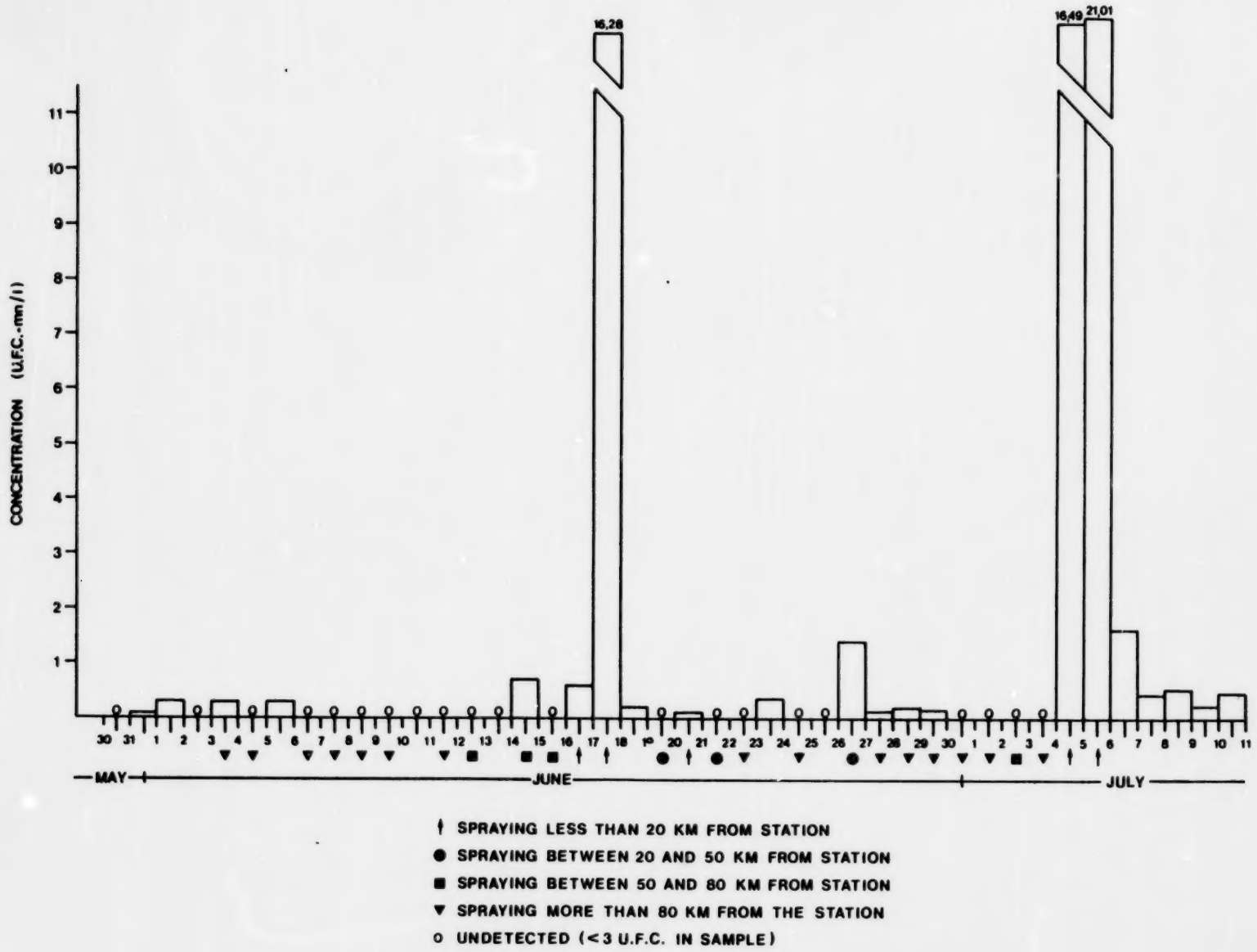

16,28
16,49
21,01
CONCENTRATION (U.F.C.-nm/l)
11
10
9
8
7
6
5
4
3
2
1
30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11
MAY
JUNE
JULY
SPRAYING LESS THAN 20 KM FROM STATION
SPRAYING BETWEEN 20 AND 50 KM FROM STATION
SPRAYING BETWEEN 50 AND 80 KM FROM STATION
SPRAYING MORE THAN 80 KM FROM THE STATION
UNDETECTED (< 3 U.F.C. IN SAMPLE)

Figure 7: Histogram of concentrations of biological insecticide (B.t.) detected at Grande-Vallée during spraying against the spruce budworm in 1985.

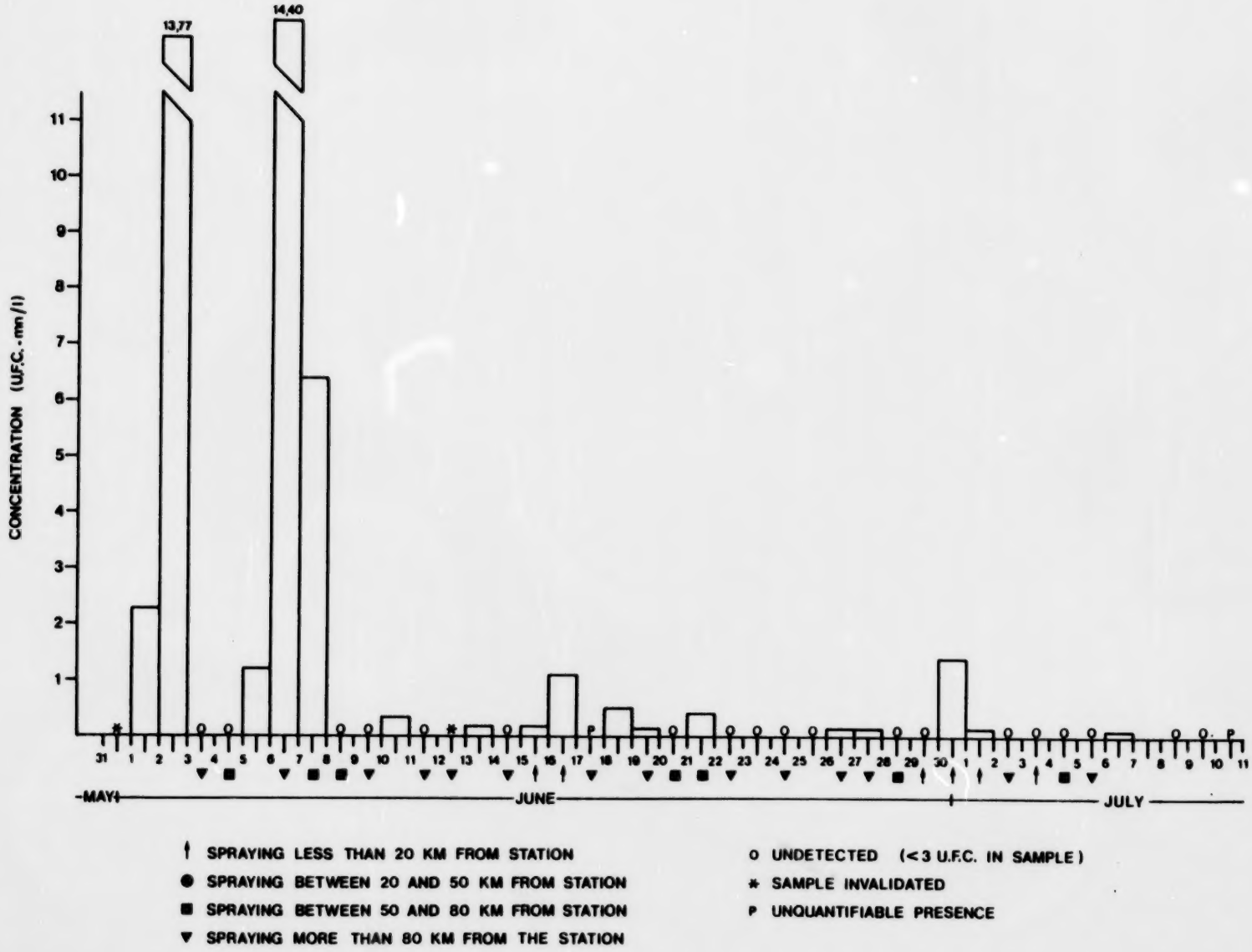

13,77
14,40
CONCENTRATION (U.F.C.-mm/l)
11
10
9
8
7
6
5
4
3
2
1
31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11
MAY
JUNE
JULY
SPRAYING LESS THAN 20 KM FROM STATION
SPRAYING BETWEEN 20 AND 50 KM FROM STATION
SPRAYING BETWEEN 50 AND 80 KM FROM STATION
SPRAYING MORE THAN 80 KM FROM THE STATION
0 UNDETECTED (< 3 U.F.C. IN SAMPLE)
* SAMPLE INVALIDATED
P UNQUANTIFIABLE PRESENCE

Figure 8: Histogram of concentrations of biological insecticide (B.t.) detected at Baie-Saint-Paul during spraying against the spruce budworm in 1985.

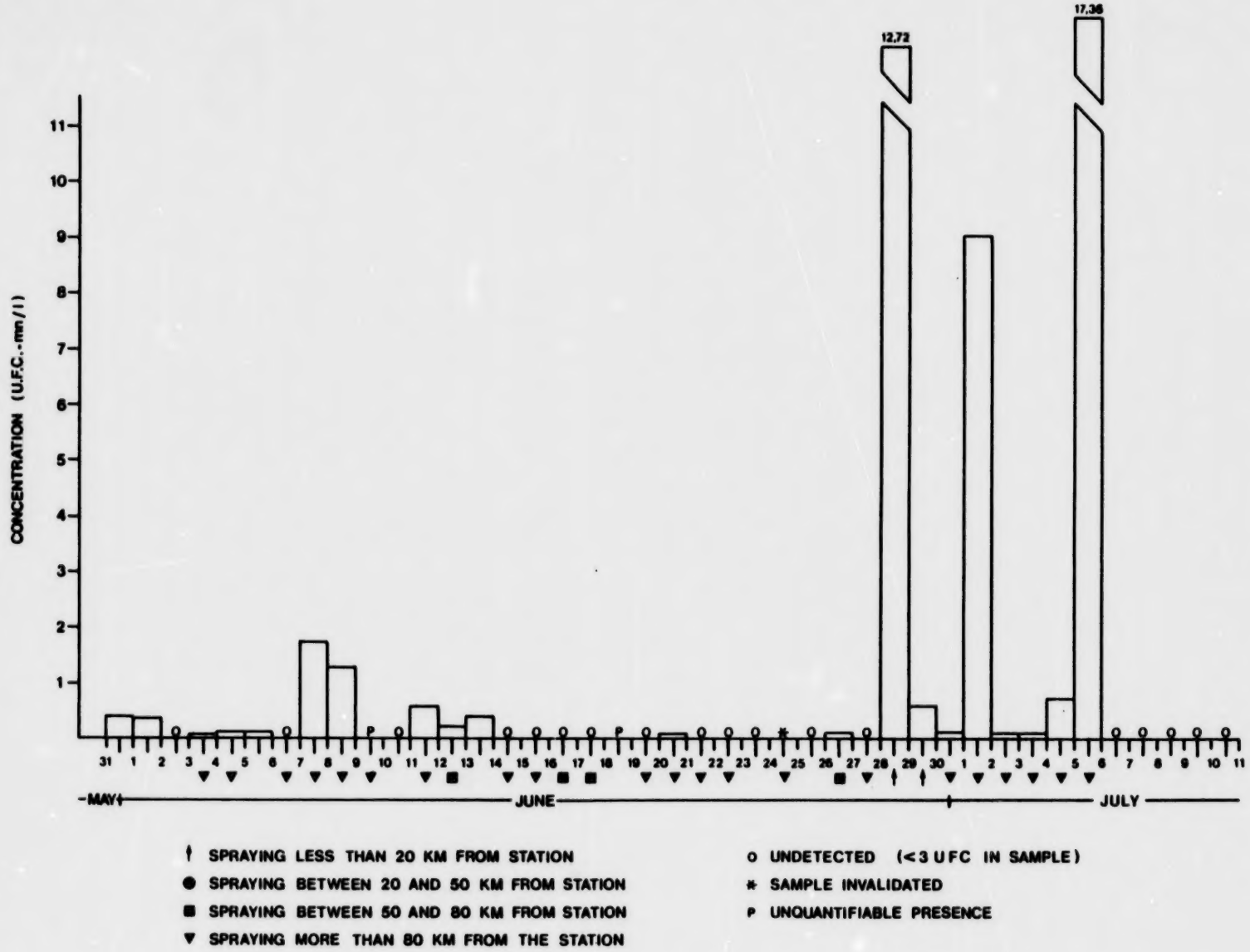

12,72
17,36
CONCENTRATION (U.F.C.-mm/l)
11
10
9
8
7
6
5
4
3
2
1
31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11
MAY
JUNE
JULY
SPRAYING LESS THAN 20 KM FROM STATION
SPRAYING BETWEEN 20 AND 50 KM FROM STATION
SPRAYING BETWEEN 50 AND 80 KM FROM STATION
SPRAYING MORE THAN 80 KM FROM THE STATION
o UNDETECTED (<3 UFC IN SAMPLE)
* SAMPLE INVALIDATED
P UNQUANTIFIABLE PRESENCE

Figure 9: Histogram of concentrations of biological insecticide (B.t.) detected at Pointe-aux-Anglais during spraying against the spruce budworm in 1985.

APPENDIX

Composition of Tween 80 and Nutrient Agar

Tween 80

Polyoxyethylene sorbitan mono-oleate 0.1% at pH 7.2

Nutrient agar

	Per liter of distilled water
- Beef extract	3 g
- Peptone	5 g
- Agar	15 g

BIBLIOGRAPHY

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